a silicon nitride layer 74 and by a silicon nitride layer 75. The thickness of the silicon nitride may be about 1000 Å. The polysilicon layers 12 and 72 may be approximately 2 microns in thickness. The polysilicon is deposited using a standard low-temperature deposition process which creates a low residual stress body or plate. Each of the plates 14 and 16 may be 800 microns or more in width, and the supporting arms may be about 40 microns or less in width.

The plate 16 indicated in FIG. 2B and the arms 36 and 32 illustrated in FIG. 2B are delineated by photolithography and by selective plasma etching. The etching removes the polysilicon material, but it only partially removes the underlying silicon nitride 74. Following the etching process, the structure illustrated in FIG. 2B is passivated by applying a silicon nitride layer 78 over the plate 16 and the polysilicon 12. This layer 78 also covers the arms 32 and 36 as well as the arms that are not illustrated in the cross-sectional view of FIG. 2B.

The supporting arms for the plates are made purposely in a circuitous path to increase their lengths, thus minimizing thermal conduction to the silicon frame. We do not intend to restrict the scope of our invention, however, to a sensor having arms of any particular length or shape.

After the layer 78 is applied, a metal film, preferably a platinum film, preferably 1000 Å thick, is deposited using a well known electron beam deposition process or a sputter deposition process. The metal film is patterned by a conventional photolithography technique. If desired, a 100 Å film of titanium or chromium can be deposited before the platinum is deposited since titanium and chromium act as an adhesion promoter.

After the patterned metal film is applied, it is wet-etched, thus defining the heater and temperature sensing conductors 56 and 64, respectively. The resistors for the heater and the temperature sensor are entirely on the upper plane of the silicon nitride layer for each plate 16 and for layer 74. This prevents discontinuities that would be produced if the metal were to be deposited on different planes. Variances in electrical resistance for the metal patterns can be minimized in this way. High temperature annealing in nitrogen, typically at 600° for two hours, may be used to stabilize the resistance and to stabilize the temperature coefficient of resistance (TCR) of the conductors.

Another layer of silicon nitride then is applied to the top of the plate to passivate the platinum resistors, as shown at 76 in FIG. 2D. This passivation is removed at the contact pads, as shown in FIG. 2E at 58 and 66. It is removed by lithography and plasma etching using SF6 material, a well known plasma etching compound.

The narrow openings shown at 79 and 80 in FIG. 2E are created as the silicon nitride layers at those regions identified by reference numerals 74, 76 and 78 are removed by plasma etching, thereby exposing the silicon substrate 10 in the region of the openings 79 and 80. An opening through layers 72 and 75 on the other side of the wafer or plate is also provided using photolithography and plasma etching. The bulk silicon of the substrate 10 is wet etched in potassium hydroxide (KOH) until the polysilicon plates and the arms protected by the nitride layers are entirely released. This is illustrated in the cross-sectional view of FIG. 2F.

A catalyst material can be applied as shown in FIG. 2F at 84 to form the layer 70 shown in FIG. 1. The catalyst material can be a layer of noble metal, such as platinum or palladium, deposited through a shadow

mask. A preferred method would involve the use of a powder slurry impregnated with a catalyst or a sol-gel solution with a catalyst. A controlled volume of the sol-gel solution, if that is the deposition method used, can be dripped over the plate with a micro syringe. Because of the presence of the polysilicon arms and the openings in the surrounding nitride, the area wetted by the solution is defined by the plate itself. The amount of catalyst deposited on the plate thus can be accurately controlled. The solvent can be removed by heating.

The catalyst also can be deposited on the back side of the plate 16 with the same deposition technique used to coat the top side. In this way, the active area of the sensor is doubled because the combustible molecules in the gas in an exhaust gas environment can diffuse through the openings at either side of the polysilicon arms to the back side of the plate. This is a further advantage of our invention over prior art constructions that use a membrane for supporting the resistor elements and the catalyst without any provision for making the underside of the membrane and the resistors accessible to combustible gases.

Another advantage inherent in our design that is not realized in prior art devices results from the use of support plates of low residual stresses. These can be easily fabricated using polysilicon. The plates thus are capable of withstanding thermal cycling without deterioration.

For purposes of this description, we have shown in FIGS. 2A through 2F the process steps for fabricating the sensor plate 16. The process for fabricating the sensor plate 14 would be the same as that described for sensor plate 16 except that the step of applying a catalyst to sensor plate 14 is not carried out.

FIG. 3 shows the functional relationship between the concentration of various gases in the gas flow passing over the sensor and the resistance difference of the two temperature sensing resistors. The active sensing resistor and the reference sensing resistor can be connected in a Wheatstone bridge configuration to two external resistors, approximately equal in value to the resistance of the reference resistor. Thus, the rise in temperature generated by the reaction of the combustible gases on the catalyst can be derived from the bridge offset voltage, knowing the initial resistance values.

The temperature rise that produces the change in resistance for each of the gases in FIG. 3 is indicated on the right-hand ordinate of the plot. The temperature change is determined from the change in the resistance in the thermometer resistor and its previously measured temperature coefficient of resistance. The resistance of the two resistors can be represented by the following equations:

$$R_{catalytic} = R_0[1 + \alpha(T + \Delta T_{comb})]$$

$$R_{reference} = R_0[1 + \alpha T]$$

In these equations, R_0 is the resistance at 0° C., α is the temperature coefficient of resistance, T is the temperature of operation in degrees C, and ΔT_{comb} is the rise in temperature caused by the oxidation of the combustible gases on the catalytic layer. The two equations can be solved for ΔT_{comb} as follows:

$$\Delta T_{comb} = (R_{catalytic} - R_{reference})/\alpha R_0 \Delta R/\alpha R_0$$